Notes on Dipterocarps.

No. 8. On some large-fruited species, and in particular upon the effects of the pressure of the embryo against the interior of the fruit-wall.

By I. H. Burkill.

Dipterocarps with large fruits that are not wind-distributed occur in the genera *Dryobalanops, Shorea, Balanocarpus, Vatica, Pachynocarpus* and *Vateria*. By the kindness of Dr. F. W. Foxworthy, I have had material of some of them for study, and one *Balanocarpus maximus*, King, was the subject of Note no. 5 of this series (Jour. Str. Br. Roy. As. Soc. no. 81, 1920, p. 3). I am adding in this note observations upon *Shorea Thiseltoni*, King, and *Vatica Ridleyana*, Brandis, and also a few remarks upon a *Dryobalanops* which has the Malay name of "Koladan."

The weight of a fruit of *Shorea Thiseltoni* from the Weld Hill Forest Reserve, Kuala Kumpur, is found to be about 5.5 grammes; that of *Vatica Ridleyana* from tree no. 815 in the Botanic Gardens, Singapore, about 12.5 grammes. Neither is wind-distributed; but falls to the floor of the forest where it may be carried through small distances by rolling or by animals.

Fig. 1, a fruit of *Shorea Thiseltoni*; figs. 2 and 3, fruits of *Vatica Ridleyana*. All ½ nat. size.

Shorea Thiseltoni is one of a small number of species in the genus whose seeds contain oil as well as starch. That having been noticed, an analysis was requested from the Department of Agriculture, Federated Malay States and Straits Settlements, and kindly made through the good offices of Mr. L. Lewton-Brain by Mr. R. O. Bishop. The following is his report on seeds submitted to him from the Weld Hill Forest Reserve. "A certain number of the kernels were found to be mouldy and were excluded: the remainder were sampled and dried. The dry kernels were extracted for oil-content. The residue from oil extraction was examined for albuminoids and ash. Results:—

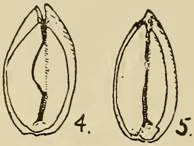
Kernel.	Moisture	34.8 per cent	
	Oil	19.5	(29.9 on dry kernel)
	Nitrogen	0.72	(4.5 albuminoids)
	Ash	1.56	

Dry residue after oil extraction

Nitrogen	1.33 per cent	(8.3 per cent albuminoid)
Ash	2.87	
Organic and volatile	97.13	

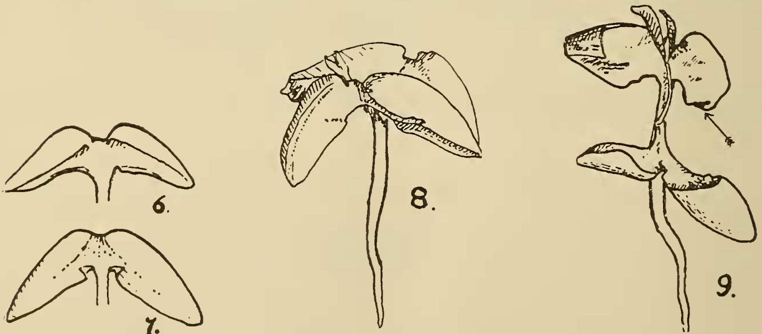
The oil immediately after extraction was liquid and with a green colour. It solidified on standing overnight and had the appearance of a tallow with a distinct odour of cocoa butter. The fat was found to have a very low acid value, the actual figure being 0.83."

The embryo has its cotyledons slightly unequal as in the following drawings where two are seen from the placentar side: the outer cotyledon is seen to be by a little the larger and alone to reach the very apex of the fruit-cavity. Great irregularity was found in the embryo: for instance in figure 4 one lobe of the placentar cotyledon is crossed partially to the wrong side of the dissepiment, and in figure 9 the two cotyledons are seen to be



Figures 4 and 5. Two embryos of *Shorea Thiseltoni* removed from the seed coats. No. 4 is slightly abnormal in that one or the lobes of the placentar cotyledon has trespassed upon the room of the other lobe. ½ nat. size.

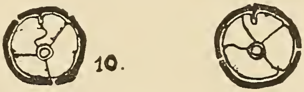
uneven. Normal expanded cotyledons are as in figures 6 and 7: in outline they are quite typical of the genus *Shorea*. Figures 8 and 9 represent the seedling, figure 8 a normal individual,—but



Figures 6 and 7, the expanded cotyledons of a seedling, No. 6 is the placentar cotyledon seen from the side towards the outer cotyledon; fig. 7 is the outer cotyledon from outside. Figures 8 and 9 two seedlings, the latter abnormal as a result of injury (? insect-puncture) at the point of the arrow. All ½ nat. size.

figure 9 one in which a lobe of the outer cotyledon has suffered injury (the arrow indicates the place), and its arrested growth has given the other lobe and the lobe of the placentar cotyledon in contact an opportunity for expansion beyond the normal. That this should happen is indicative of the pressure set up within the fruit,—the pressure which continued is also the cause of the rupture of the fruit-wall in germination, however at that period with a small amount of altered tension, due to the outer layer of the fruit wall contracting in drying somewhat more than the inner.

In my study of germinating Dipterocarps I have found no exactly similar case of a tendency in the ruptured fruit to gape and therefore it must be described in detail. The lines of rupture are variable in place, as in *Isotoma* (vide this Journal above) and are quite clearly brought about by the pressure of the growing embryo; but when they have been produced, the drying of the outer layer of the fruit-wall continues the tearing and causes the split wall to assume the appearance which is represented in figures 12, 13 and 14. This is not a hygroscopic action; and therefore no soaking of the seed brings the edges of the gaping crack together. Obviously it greatly facilitates the escape of the young plant from the imprisoning fruit-wall.


10. 11.

Figures 10 and 11, sections through the fruit of *Shorea Thiseltoni*, showing the packing of the cotyledon-lobes, and the places where in these cases the fruit-wall was split.

The fruit of *Shorea Thiseltoni* germinates without resting, and in germination the lines of splitting commence at the apex of the fruit, and extend downwards. The most usual course of events is for there to be three splits, and for two of them to extend to the base, whereon a panel of the fruit-wall is free and forced out. This panel is usually rather less than one third of the circumference: but there is great variability. The variability is accompanied by a great variability in the relative size of the lobes of the two cotyledons; and may be considered as a consequence of it, as has been suggested in the note upon *Isotoma borneensis;* and the most unusual forms of splitting were found to occur with unusual twisting or unequal development in the cotyledons.

The fruits sink in water, and may germinate submerged;* doubtless if such should happen in nature germination would be

* Lewkowitsch, (Chemical technology and analysis of Oils, Fats and Waxes, ii, London, 1914, p. 601) has a statement that submersion of the fruits of Dipterocarps is resorted to in Borneo in the preparation of Tangkawang oil because it prevents germination. This reason appears wholly incorrect: but submersion by killing the caterpillars and grubs which so freely devour the embryo within the fruits may prevent loss in manufacture.

followed very quickly by death. An experiment was made with six fruits in order to see if submergence inhibited the splitting of the fruit wall: apparently it did not; for all the six germinated in six days under water. The splitting is the work of the germinating young plant pushing itself free.

Figures 12, 13 and 14. Three empty fruits showing various degrees of gaping.

The petioles of the cotyledons elongate in germination so much as to attain 2-7 cm. pushing the radicle out to the soil before they free themselves from the fruit-wall. They possess abundant chlorophyll.

Leaving *Shorea Thiseltoni*, attention will now be directed to *Vatica Ridleyana*, Brandis.

This species grows wild in the Botanic Gardens, Singapore. It flowered in January, 1921, and bore ripe fruits from near the end of the year into the first quarter of 1922;—flowering had lasted a couple of weeks, but fruit-fall lasted three months. The considerable weight of the fruits has already been remarked: it remains to call attention to the circumstance that their growth from flowering to maturity takes twice as long as that of the smaller and closely allied *V. Wallichii*.

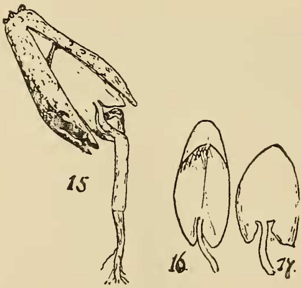


Figure 15. A seedling of *Vatica Ridleyana* in germination, the stalks of the cotyledons pushing the plantlet into the soil. The outer cotyledon is towards the observer; above it a little of the placentar cotyledon is visible. Figure 16, the placentar cotyledon from the surface in contact with the outer cotyledon. Figure 17, the outer cotyledon from outside. All ½ nat. size.

The placentar cotyledon is the larger and fills the lower part of the fruit-cavity to the exclusion of the outer cotyledon; but it shares equally the upper part of the cavity. The result is that its bulk is nearly twice that of the outer cotyledon. In *Balanocar-*

pus maximus the placentar cotyledon occupies the basal part of the cavity of the fruit and the outer cotyledon the apical; and they are of nearly equal bulk: in *Vatica Wallichii,* they are also of nearly equal bulk and they share the fruit-cavity equally, but side by side instead of as in *Balanocarpus* the one above the other: but in *Vatica Ridleyana* with inequality, the placentar cotyledon occupies the basal and shares the apical part.

There is enwraping neither in *Vatica Ridleyana* nor in *Vatica Wallichii;* and the cells in both are gorged with starch. The young plant after emergence is singularly similar in the two, the leaves are exactly alike, even to the 6-8 large glands upon the lower surface at the looping of the veins, surrounded by the richest green of chlorophyll. Unlike the fruits of *Vatica Wallichii,* the fruits of *Vatica Ridleyana* do not float in water, not even if dried.

In germination the fibrous fruit-wall splits from the apex downwards along pre-determined lines, possibly along one line to its base and for a short way only along others: the radicle is thrust out by the elongation of the petioles of the cotyledons, as in *Vatica Wallichii, Shorea robusta,* the genus *Dipterocarpus.* The blades of the cotyledons never leave the fruit-cavity, but develop a little,—very little—chlorophyll where they become exposed to the light.

The lines where the fruit-wall is split in germination, can be seen beforehand upon the outer side of the fruit, as they are depressed and free from the elsewhere abundant lenticels. The fruit-wall is thinner at them and the cell-structure differs.

These lines are usually three, but may be four and may be five in number. In studying the flower when it was available in January, 1921, (see this Journal p. 276), five-locular ovaries were not observed; but as their presence was not suspected, no search was made for them: it was only when, twelve months later, the fruit was ripe that their existence was suggested by finding five lines of splitting in a small percentage of the fruits.

Out of 263 fruits, 201 had three lines, 57 had four lines, and 5 had five lines.

It is most interesting that when the fruit shows four depressed lines upon the outside, three only as a rule are burst open, so that out of 17 fruits with four lines, set to germinate together, 15 were split along three and 2 only along four lines. Of the first fifteen in 13 the line which was not split was that close to the placenta.

Four fruits with five depressed lines, set to germinate at the same time likewise became split along three only of the lines, and again a line not split was that closest to the placenta.

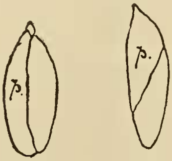
That these lines are the places where the carpels are connate into the ovary admits of doubt because in fruits with four lines, the placenta is rarely central upon any one of the valves. The development must be followed out to demonstrate that it is as one would expect. The fruit-wall is composed of brown parenchymatous cells, white sclerenchyma fibres and a margin of cork with numerous powdery lenticels.

The sclerenchyma fibres are in bundles of 8-30 and anastomose; but not across the lines where the fruit-wall is ruptured. In their absence at these spots lies the weakness which associated with a slightly lesser thickness, locates the rupture of the dead tissues under the pressure of the growing seedling within.

A comparative study of the distribution of these sclerenchyma fibres in the fruit-wall of the Dipterocarps, and above all of their relationship to the way in which the young plant makes it way out, seems to be most desirable; but it will be a long time before sufficient material for it can be got together.

Before the fruit-wall gives way, the growing embryo has endured a period of compression: and if the distribution of the pressure is made abnormal, it stows itself in a modified way. Insect-punctures and other forms of injury to the fruit-wall change this pressure: and a slightly greater resistance to being pushed against the wall in the placentae of the tree 815 appears to be the force which leads to so many of that tree's fruits curving as in figure 2 above. In these curved fruits the placenta is along the less convex side, and the dorsal cotyledon almost always just excludes the placentar from the apex of the fruit cavity. In a more or less straight fruit the embryo in side view is thus:—

both cotyledons reaching the apex, but the placentar alone the base. But with the pressure abnormal and particularly if the injury has passed through the fruit wall reaching the embryo as for instance a Hemipteron's tongue is generally meant to do, various changes affecting sometimes one side, sometimes another side of the embryo, appear; the embryo may then be unilateral or the dorsal cotyledon may have lost position or the placentar coyledon as in the two further diagrams here following. In the one the placentar cotyledon seems to have sustained a set back; and in the other the



dorsal, the results of which have been in the one to produce an embryo closely similar to that of *Vatica Wallichii* (see Jour. Str. Br. Roy. As. Soc. no. 81, p. 76, figures 209-212), and in the other an embryo suggesting somewhat that of *Balanocarpus maximus* (see p. 4 of the same).

The lesson to which these observations seems to point, is that the embryo of Dipterocarps possesses a considerable amount of plasticity.

This note closes with a few remarks upon the Malayan *Dryobalanops* known as "Koladan," * a member of its genus which uses the wind in no way for the transport of its fruits. They are as here drawn, and in germination the wall is split along three lines

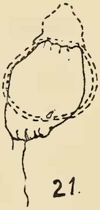
18.

19.

Figure 18. A fruit of Koladan, showing an obliquity by no means uncommon, the placentar side being smaller than the other. Figure 19 the same seen from the end showing which of the cracks usually it forced open the most: the placenta is uppermost.

in exactly the same way as in *Dryobalanops aromatica.* The embryo is further as in that species (vide No. 4, Jour. Straits Branch Roy. As. Soc., No. 81, 1920, p. 56) and so also is the young seedling. It was not remarked of that species; but may now be remarked after studing *Koladan* somewhat, that the seedling has a great tendency to force rupture along two lines and to come to the light by pushing aside a panel of the wall which is diametrically opposite to the placenta.

20.



21.

Figure 20. A seedling of ''Koladan'' in the position in which is throws off its seedcoats and the fruit wall.

Figure 21 shows the fruit wall in broken dotted lines imposed over an outline of a seedling in germination to indicate where the greatest pressure appears to occur.

---

* Dryobalanops sp.—Koladan, Foxworthy in Malayan Science Bulletin, vol. I, 1921, p. 76.